IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR

UNITED STATES LETTER PATENT

FOR

ELECTRONIC TRACK LIGHTING SYSTEM

S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

Be it known that I, OLE KRISTIAN NILSSEN, a citizen of Norway, residing at Caesar Drive, Route 5, Barrington, Illinois, County of Cook, United States of America, have invented an

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ELECTRONIC TRACK LIGHTING SYSTEM

of which the following is a specification.

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to track lighting systems, particularly of a kind that is being powered by way of a frequency-converting power supply and in such a way that the track voltage is of substantially normal magnitude (120 Volt RMS) but of a much higher than normal frequency (20-40 kHz).

Related Applications

This application is a Continuation-in-Part of application Serial No. 07/387,370 filed 07/31/89; which is a Continuation of application Serial No. 07/108,963 filed 10/16/87, now abandoned; which was a Continuation of application Serial No. 06/471,132 filed 03/01/83, now abandoned.

Also, this application relates to co-pending application Serial No. 07/470,322 ~~06/837,759~~ filed 01/25/90 ~~04/15/86~~.

Description of Prior Art

Track lighting systems are being manufactured by a number of different companies. One such company is Halo Lighting Division of McGraw-Edison Company, Elk Grove Village, Illinois 60007; whose track lighting systems and products are described in their Catalog No. A8100.

Conventional track lighting systems are designed to operate from a conventional utility power line and to have regular 120Volt/60Hz voltage on the track. The lighting units plugged into the track must be able to operate directly from this 120Volt/60Hz voltage.

Low voltage incandescent lamps, particularly 12 Volt Halogen lamps, have proven to be particularly attractive for track lighting purposes, and are being used to a growing degree. However, these low-voltage/Halogen lamps are designed to operate at a voltage of 12 Volt or less, and therefore have to be powered by way of voltage step-down transformation means. Thus, at present, whenever low-voltage/Halogen lamps are being used in track lighting systems, each such low-voltage/Halogen lamp has to be powered by way of such a voltage step-down transformation means; which implies that each lighting unit has to contain such a voltage step-down transformation means -- a practice that results in costly, large and heavy track lighting units.

The use of a single large step-down transformation means capable of providing power at a suitably low voltage to the complete track has been considered and tried. However, the resulting track current becomes prohibitively large for most applications.

(Since a conventional track is designed to handle a current of not more than 16 Amp, it would only be capable of powering three or four typical low-voltage/Halogen lamps, which is far fewer than the number of lamps that would be required in most applications.)

SUMMARY OF THE INVENTION

Objects of the Invention

A first object of the present invention is that of a power-line-operated track lighting system that is particularly suitable for use with low-voltage incandescent lamps.

A second object is that of a track lighting system wherein the track is provided with a voltage of magnitude substantially equal to that of regular power line voltages but of a frequency substantially higher than those of regular power line voltages.

These as well as other objects, features and advantages of the present invention will become apparent from the following description and claims.

Brief Description

The present invention relates to means by which the track (or tracks) in a power-line-operated track lighting system is provided with a voltage of magnitude substantially equal to that of the voltage on the power line (120 Volt RMS), but of frequency much higher than that of the power line voltage.

In the preferred embodiment, this higher frequency is approximately 30 kHz; and this 30 kHz track voltage is obtained by way of a power-line-operated full-bridge inverter located at the head of the power track and feeding its output to the track conductors.

With such a high frequency on the track, and with the voltage being approximately of 120 Volt RMS magnitude, the voltage step-down transformation means required for operating low-voltage incandescent lamps (particularly 12 Volt Halogen lamps) are far smaller, lighter and lower in cost as compared with their 60 Hz counterparts.

At the same time, regular 120 Volt incandescent lamps may be used on the track, usually without any voltage transformation means.

Brief Description of the Drawings

Fig. 1 diagrammatically illustrates a typical track lighting system.

Fig. 2 diagrammatically illustrates the electrical circuit arrangement of a typical present track lighting system.

Fig. 3 diagrammatically illustrates the electrical circuit arrangement of the preferred embodiment of subject invention.

Fig. 4 represents a schematic circuit diagram of the frequency-converting power supply used in the preferred embodiment.

~~Fig. 5 illustrates typical voltage and current waveforms associated with the frequency-converting power supply.~~

DESCRIPTION OF THE PREFERRED EMBODIMENT

Description of the Drawings

In Fig. 1, JB represents an electrical junction box in a ceiling CL. Fastened to and extending along the ceiling from this junction box is an electrical track means TM. This track means comprises a slot means SM by way of which a number of track lighting units TLU1, TLU2, ---- TLUn are removably fastened to and connected with the track.

In Fig. 2, a source S provides a 120Volt/60Hz power line voltage across a pair of power line wires PLW, which power line wires enter junction box JB. A pair of track conductors TC connect directly with these power line wires. These track conductors exit from the junction box and extend for the length of track means TM. Disconnectably connected with the track conductors are a number of conventional track lighting units CTLU1, CTLU2 --- CTLUn.

Track lighting unit CTLU1 comprises an ordinary 120 Volt incandescent lamp IL, the electrical terminals of which are disconnectably connected directly across the track conductors.

Track lighting unit CTLU2 comprises a 12 Volt Halogen lamp HL, the electrical terminals of which are connected with the

secondary winding of a conventional 60 Hz step-down voltage transformer CVT. The primary winding of this transformer is disconnectably connected directly across the track conductors.

In Fig. 3, power line wires PLW from source S enter junction box JB wherein they connect with power input terminals PIT of frequency-converting power supply FCPS. The output from frequency-converting power supply FCPS, which is an AC voltage of about 120 Volt RMS magnitude and 30 kHz frequency, is provided at power output terminals POT; which power output terminals are connected with track conductors TC. These track conductors exit from the junction box and extend for the length of track means TM. Disconnectably connected with the track conductors are a number of high-frequency track lighting units HFTLU1, HFTLU2 --- HFTLUn.

High-frequency track lighting unit HFTLU1 comprises an ordinary 120 Volt incandescent lamp IL, the electrical terminals of which are disconnectably connected directly across the track conductors.

High-frequency track lighting unit HFTLU2 comprises a low voltage (12 Volt) Halogen lamp HL, the electrical terminals of which are connected across the secondary winding of a small high-frequency step-down voltage transformer HFSDVT. The primary winding of this transformer is disconnectably connected directly across the track conductors.

Fig. 4 constitutes an electric circuit diagram of frequency-converting power supply FCPS.

In Fig. 4, a bridge rectifier BR has a pair of power input terminals PIT adapted to connect with ordinary 120Volt/60Hz power line voltage.

The positive voltage output from rectifier BR is connected with a B+ bus; and the negative voltage output from rectifier BR is connected with a B- bus. A capacitor C1 is connected betweeen the B+ bus and the B- bus.

A transistor Qa1 is connected with its collector to the B+ bus and with its emitter to a junction Ja. Another transistor Qa2 is connected with its collector to junction Ja and with its emitter to the B- bus.

Similarly, a transistor Qb1 is connected with its collector to the B+ bus and with its emitter to a junction Jb; while yet another transistor Qb2 is connected with its collector to junction Jb and with its emitter to the B- bus.

The base of transistor Qa1 is connected with junction Ja by way of secondary winding SWa1 on current transformer CTa1; and the base of transistor Qa2 is connected with the B- bus by way of secondary winding SWa2 of current transformer CTa2.

Similarly, the base of transistor Qb1 is connected with junction Jb by way of secondary winding SWb1 on current transformer CTb1; and the base of transistor Qb2 is connected with the B- bus by way of secondary winding SWb2 of current transformer CTb2.

An output terminal OTa is connected with junction Ja by way of series-connected primary windings PWa1 and PWa2 of current transformers CTa1 and CTa2, respectively.

Another output terminal OTb is connected with junction Jb by way of series-connected primary windings PWb1 and PWb2 of current transformers CTb1 and CTb2, respectively.

Output terminals OTa and OTb are connected with power output terminals POT by way of a non-linear inductor NLI.

A capacitor Ct is connected between the B+ bus and a junction Jt; and a resistor Rt is connected between junction Jt and the B- bus. A Diac D1 is connected between junction Jt and the B+ bus by way of series-connected tertiary windings TWa and TWb of current transformers CTa1 and CTb2, respectively.

Details of Operation

The operation of an ordinary track lighting system, such as the one illustrated in Fig. 1, is well understood. In particular, it involves the mounting of a track onto and along a surface, such as a ceiling; which track comprises a slot that is capable of receiving, holding and powering a number of various types of track lighting units. Any one or all of these track lighting units can readily be removed from and/or moved along the track.

When a track lighting unit is inserted into the slot, it makes electrical contact with a pair of conductors therein; from which pair of conductors it gets its operating power.

For further information with respect to ordinary track lighting systems, as well as with respect to a track lighting system designed for powering the track conductors with a voltage of 12 Volt RMS magnitude, reference is made to U.S. Patent No. 4,414,617 to Galindo.

As illustrated by Fig. 2, in a conventional track lighting system, the track operating power is provided in the form of an ordinary 120Volt/60Hz voltage; which voltage is provided to

the conductors in the track directly from a conventional electric utility power line.

As illustrated by Fig. 3, in a track lighting system according to the present invention, the track operating power is provided in the form of 120Volt/30kHz voltage; which voltage is provided to the track from the output of frequency-converting power supply FCPS.

Frequency-converting power supply, which operates in the manner described hereinbelow, is powered from the ordinary 120Volt/60Hz power line voltage provided by an ordinary electric utility power line.

With a 120Volt/30 kHz voltage on the track, it becomes particularly simple and cost-effective to provide for various voltage transformations and/or current limitations, etc. -- as required by the various lighting means useful in track lighting.

For instance, in respect to lighting unit HFTLU1, no transformation means at all is required for an ordinary 120 Volt incandescent lamp; which, of course, is not any different from the case with 120Volt/60Hz on the track.

On the other hand, in respect to lighting unit HFTLU2, a transformer means must be used to provide the requisite voltage step-down transformation required by the 12 Volt Halogen lamp used therein. However, with the frequency of the track voltage being so high, the size, weight and cost of this transformer are substantially smaller than those of the transformer required in lighting unit CTLU2 of the conventional track lighting system.

Frequency-converting power supply FCPS of Fig. 4 comprises a bridge rectifier (BR) operative to provide unfiltered full-wave-rectified 120Volt/60Hz power line voltage between the B+ bus and the B- bus. The purpose of capacitor C1 is that of providing a low-impedance path for 30 kHz inverter currents. However, it provides substantially no filtering for the full-wave-rectified power line voltage present between the B+ bus and the B- bus.

Thus, the voltage applied to the full-bridge inverter, which consists principally of transistors Qa1, Qa2, Qb1 and Qb2, is a series of sinusoidally-shaped unidirectional voltage pulses provided at the rate of 120 pulses per second. The RMS magnitude of this pulsed DC voltage is 120 Volt -- just as is the RMS magnitude of the AC voltage applied to the full-bridge rectifier means BR.

In other words, the RMS magnitude of the DC voltage applied to the full-bridge inverter is 120 Volt; which -- as long as the inverter oscillates -- makes the RMS magnitude of the inverter output voltage also 120 Volt.

Otherwise, except for the function of non-linear inductor NLI, the operation of the full-bridge inverter of Fig. 4 is entirely analogous to that of the half-bridge inverter described in U.S. Patent No. 4,506,318 to Nilssen.

The inverter self-oscillates by way of current feedback provided by the four positive feedback current transformers CTa1, CTa2, CTb1 and CTb2; which means that the inverter will not oscillate without having a load connected between its power output terminals POT. Thus, the inverter used in the frequency converter of Fig. 1 stops oscillating whenever special light bulb SLB is switched OFF or removed.

The function of non-linear inductor NLI relates to the fact that the load presented to power output terminals POT is substantially resistive and may vary from as little as a single 20 Watt lamp to as much as, say, ten 50 Watt lamps. The function of non-linear inductor NLI is that of providing an inductance in series with the resistive load; which inductance is of such nature as to represent: (i) a relatively high inductance value as long as the load current is relatively small (i.e., for relatively light loads); but (ii) due to saturation, a relatively low inductance value for relatively high loads. That way, regardless of the magnitude of the output current, the inductor provides for a brief delay in the reduction (or reversal) of load current in response to a reduction (or reversal) of the magnitude of the inverter's output voltage; which brief delay will be present at all different levels of load and will help prevent destructive and/or highly dissipative common-mode conduction of the switching transistors; which common-mode conduction results from transistor storage time effects. The net effect of the non-linear inductor on the effective or RMS magnitude of the output voltage will be negligible; which is to say: as long as the inverter indeed oscillates, the absolute instantaneous magnitude of the inverter's output voltage will at all times be substantially equal to the absolute instantaneous magnitude of the DC supply voltage existing between the B- bus and the B+ bus. And, of course, as an inherent result of full-wave rectification, the absolute instantaneous magnitude of this DC supply voltage is substantially equal to that of the power line voltage provided at power input terminals PIT.

Thus, as long as the inverter of frequency-converting power supply PCPS indeed oscillates, the voltage present across power output terminals POT is a 30 kHz squarewave voltage with an absolute instantaneous magnitude about equal to that of the power line voltage provided at power input terminals PIT.

In fact, as long as the inverter indeed oscillates, since the forward voltage drops of the rectifiers and transistors are each of negligible magnitude, and since the voltage drops across the primary windings of the four current transformers are each of negligible magnitude, and since the net effective voltage drop across non-linear inductor NLI is of negligible magnitude, then the absolute instantaneous magnitude of the output voltage present across power output terminals POT must inherently be substantially equal to that of the input voltage present across power input terminals PIT -- as long as the magnitude of this input voltage is substantially larger than the sum of the various voltage drops.

As seen from another perspective, the function of the inverter is simply that of rapidly switching each one of the output terminals (f.ex. OTa) back and forth between the B- bus and the B+ bus. As a result, during any given half-cycle of the power line voltage, the inverter simply operates to rapidly (at a 30 kHz rate) switch each one of its output terminals (f.ex. OTa) between the two power line conductors (as connected with terminals PIT). Thus, with reference to Fig. 3, frequency-converting power supply FCPS simply acts to connect power line wires PLW with track conductors TC in a rapidly reversing manner -- as if the two pairs of wires were connected by way of a rapidly reversing (or oscillating) four-pole reversing switch. This inherently means that one of the track conductors is always electrically connected with one of the power line wires; which, in turn, means that the electrical potential of one of the track conductors is always equal to the electrical potential of one or the other of the conductors of the power line wires.

Additional Comments

(a) Without having to resort to the use of a power transformer, subject invention provides for the flexibility of furnishing voltages to the track that are of significantly different magnitudes than 120 Volt RMS. For instance, by using a half-bridge inverter, it is readily possible -- without the use of a voltage transformer -- to furnish the track with a voltage of 60 Volt RMS magnitude even if the power line voltage is 120 Volt.

(b) Transformer HFSDVT of the track lighting arrangement of Fig. 3 is designed to be powered at its primary winding with a voltage of about 30 kHz frequency. The transformer would not function at all if it were to be powered at its primary winding with a voltage of ordinary power line frequency (i.e., 60 Hz).

(c) In the frequency-conversion circuit of Fig. 4, an important characteristic is that there always exists an electrically conductive path between either one of power output terminals POT and either one of power input terminals POT.

(d) As long as the frequency-converting power supply (FCPS) is in actual operation, the output voltage provided at power output terminals POT is a squarewave voltage of frequency equal to about 30 kHz and with absolute instantaneous magnitude about equal to that of the power line voltage provided at power input terminals POT; which is to say that, at any moment in time, the absolute magnitude of the voltage existing between track conductors TC is substantially equal to that of the power line voltage existing between power input terminals PIT.

(e) It is believed that the present invention and its several attendant advantages and features will be understood from the preceeding description. However, without departing from the spirit of the invention, changes may be made in its form and in the construction and interrelationships of its component parts, the form herein presented merely representing the preferred embodiment.